

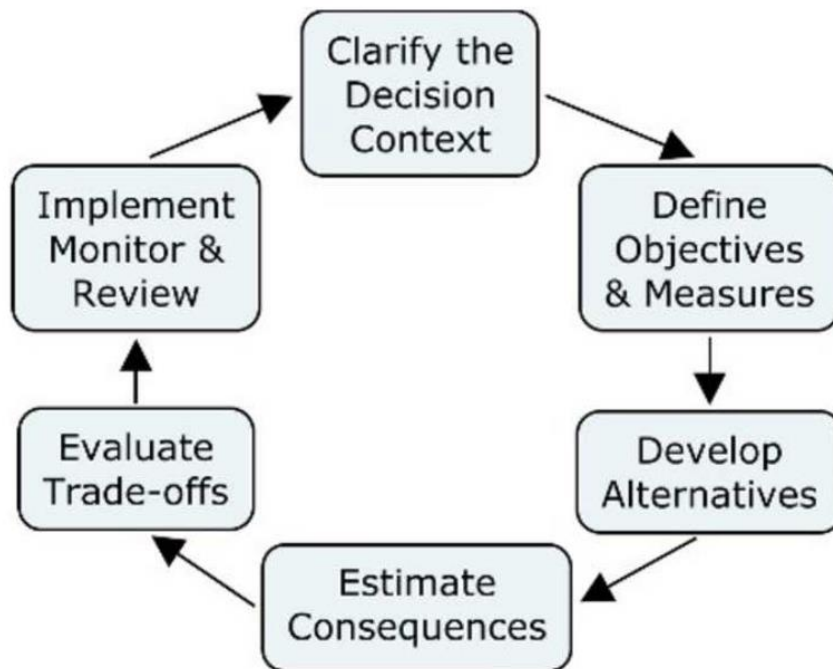
# Advancing a Structured Decision Process for Coral Reef Protection



**Bill Fisher, US EPA Gulf Ecology Division  
Coastal Resilience Conference, New Orleans LA  
May 23, 2014**

# Structured Decision Making

A process to elicit and organize key *stakeholder values* and relevant *scientific knowledge* for making decisions



## Strengths of SDM

- Facts and values
- Multiple perspectives
- Holistic
- Democratic
- Flexible
- Multiple knowledge sources

# Preliminary Decision Context

## Coral Reef Protection near Guánica Bay

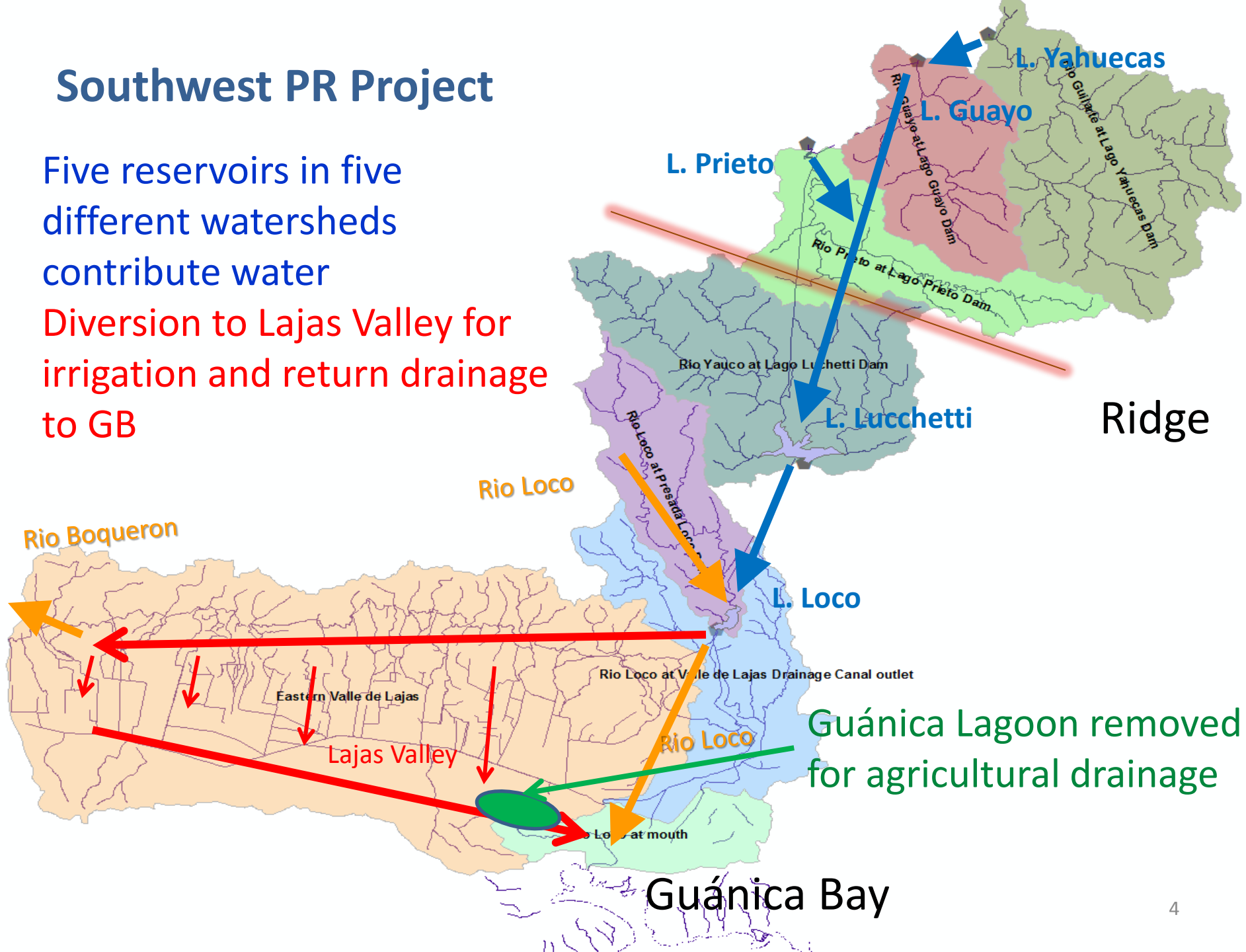
- Landuse changes – agriculture and municipal growth
- Sediment, nutrients, contaminants flowing into Guánica Bay and coastal zone
- Concern over the effects to corals led to a US Coral Reef Task Force watershed initiative to reduce watershed stressors



# Southwest PR Project

Five reservoirs in five different watersheds contribute water

Diversion to Lajas Valley for irrigation and return drainage to GB





# Guánica Bay Watershed Management Plan: Proposed Actions

Conversion to shade-grown coffee

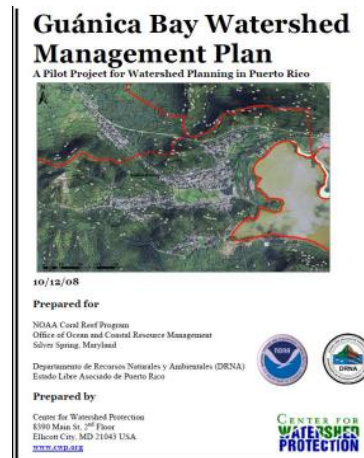
Dredging reservoirs

Lagoon restoration

Hydro-seeding

Riparian planting

Removal of relic irrigation  
structures



# Guanica Bay Watershed Management Plan

## Management Actions

Cover Crops  
Shade-grown coffee

Lagoon restoration

Dredge reservoirs  
Reservoir releases

Rainwater collection

Riparian plantings  
Remove relic irrigation  
structures

Pet waste cleanup  
Wetland treatment of  
sewage effluent

## Rationale

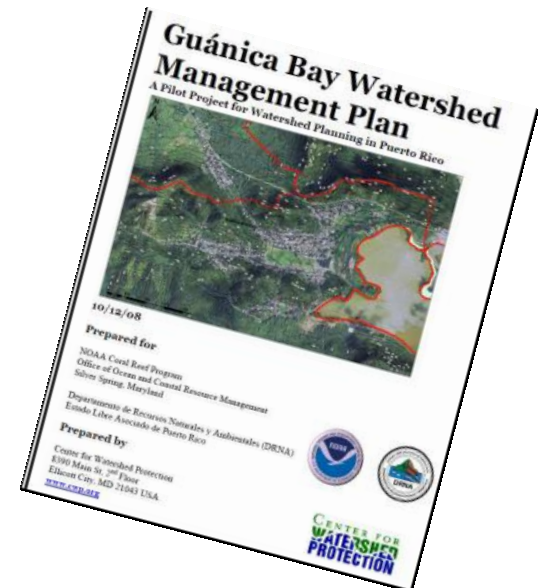
Reduce physical/  
chemical stressors  
in water

Reduce biological  
stressors in water

## Objective

Maximize ecological integrity

Coral reefs



# Guanica Bay Watershed Management Plan

Are these our only options?

## Management Actions

- Cover Crops  
Shade-grown coffee
- Lagoon restoration
- Dredge reservoirs  
Reservoir releases
- Rainwater collection
- Riparian plantings  
Remove relic irrigation structures
- Pet waste cleanup  
Wetland treatment of sewage effluent

How were these solutions chosen?

## Rationale

Reduce physical/  
chemical stressors  
in water

Reduce biological  
stressors in water

## Objective

Was this the best plan? Was this reviewed?

Are sediments & nutrients really affecting corals in GB?

Maximize ecological integrity

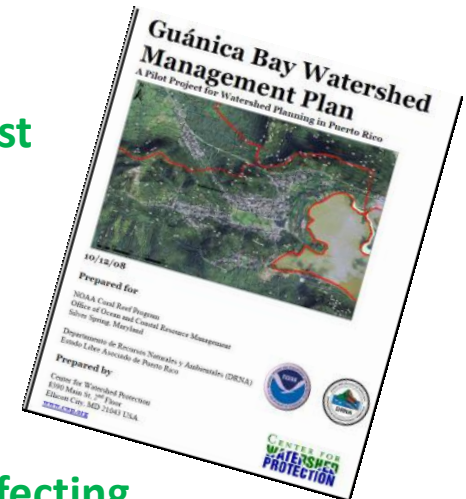
Coral reefs

Is this really our objective?

What are the performance measures?

When have we done enough?

What are the tradeoffs? Are there unintended consequences? Who are winners and losers?



# Stakeholder Engagement



## **Decision Workshop on Watershed Mgmt Plan 2010**

Proposed management options  
Systems (DPSIR) framework  
Ecosystem goods and services

## **Historic Decisions Workshop 2012**

Desire for local empowerment in decisions  
Desire for equitable opportunities  
Better enforcement of regulations

## **Coral Reef Condition Workshop 2012**

Objectives for management and regulatory  
protection of coral reefs  
Attributes and measurements for reef protection

## **Public Values Forum 2013**

Identify broader stakeholder objectives  
Examine tradeoffs and consequences of decisions  
Prioritizations for achieving multiple values

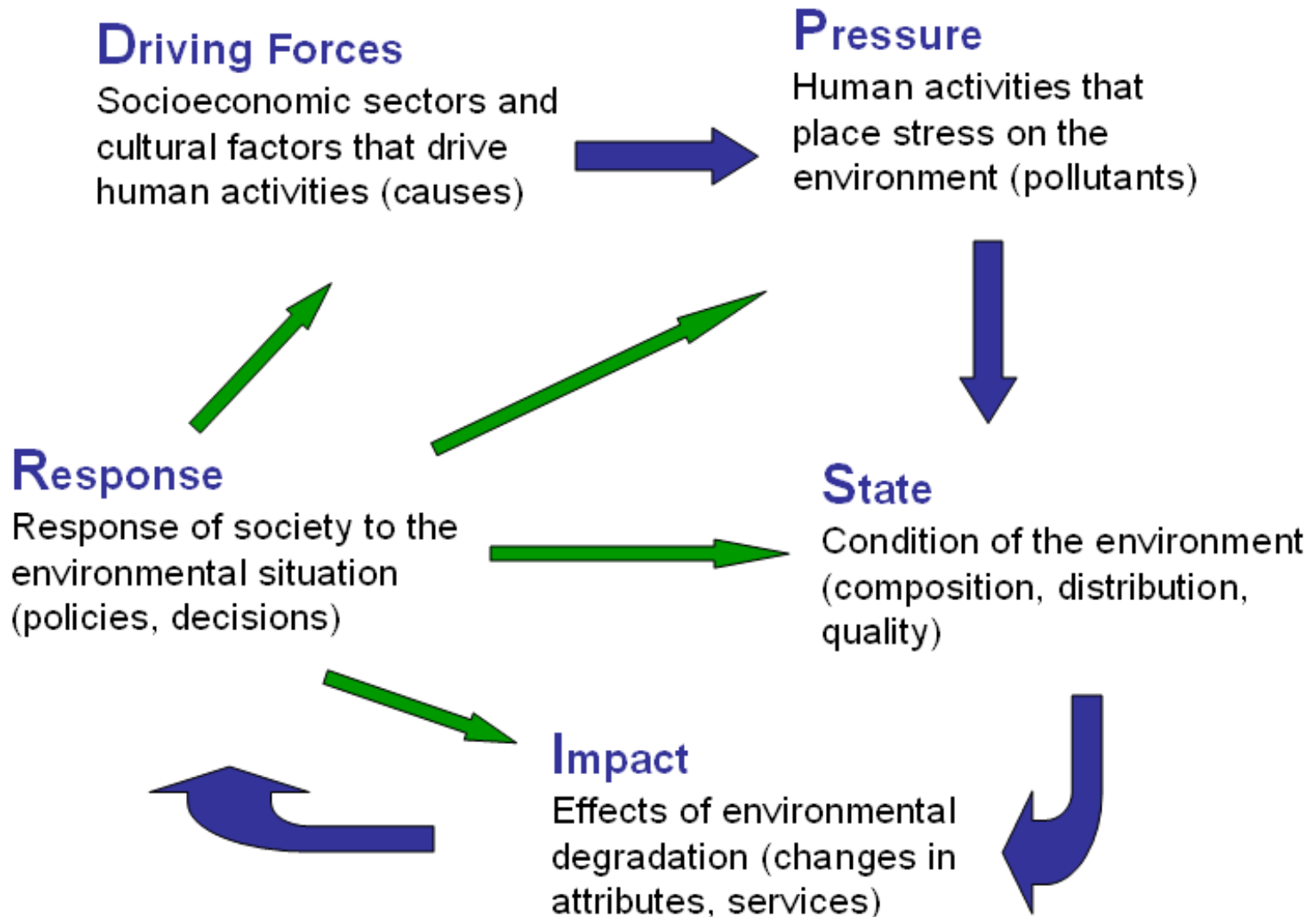


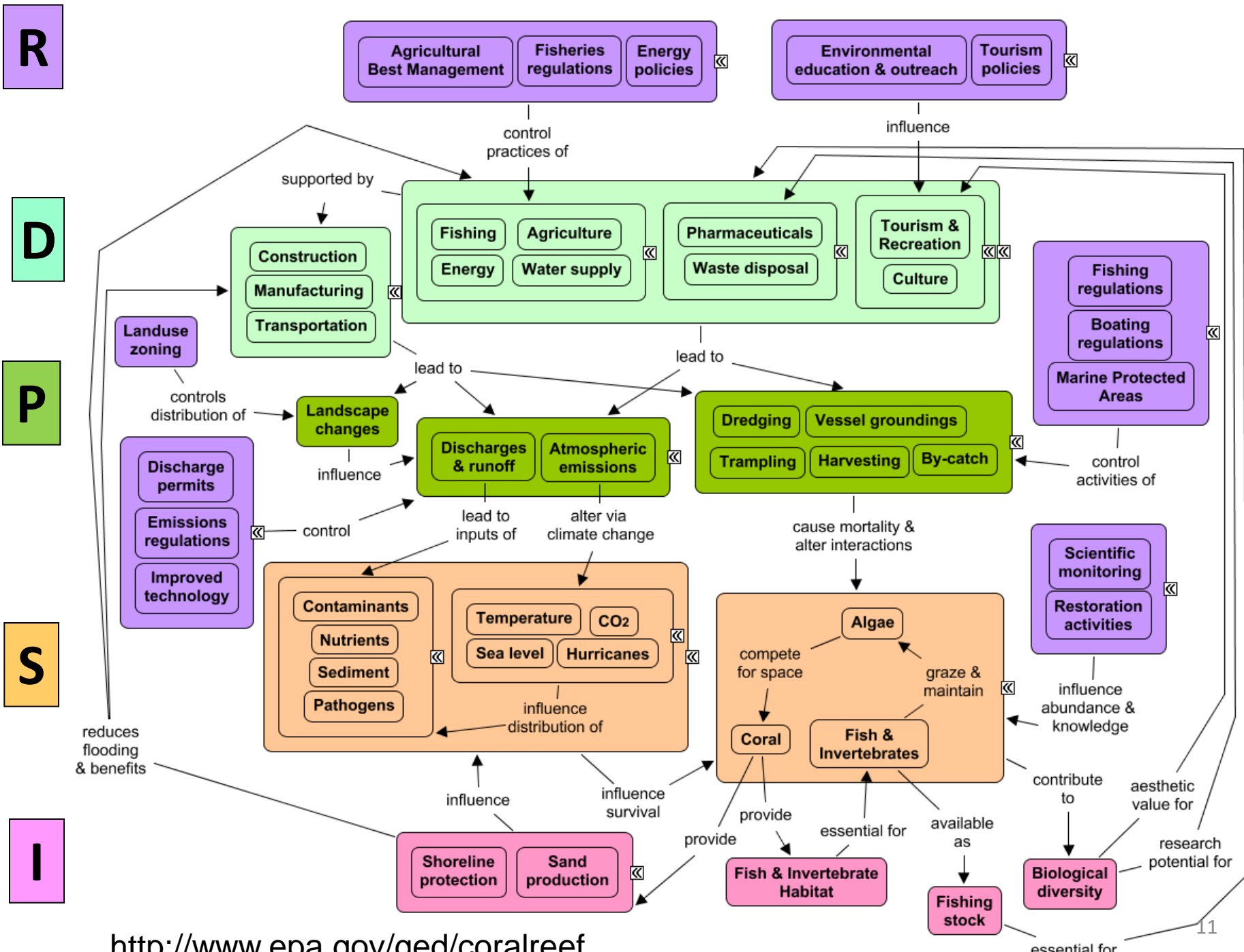
# So many issues.....

Tourism policies  
 Coral bleaching  
 Predation  
 Economic Values  
 Marine Protected Areas  
 Sewage  
 Energy management  
 Hurricanes  
 Fishing  
 Coral Disease  
 Habitat  
 Sediment  
 Mangroves  
 Agriculture  
 Ecosystem services  
 Seagrasses  
 Nutrients  
 Beach replenishment  
 Diving/snorkeling  
 Sea turtles  
 Diadema  
 Algae  
 Restoration  
 Ocean acidification  
 Climate change  
 Upwelling  
 Groundings  
 Acropora  
 Lionfish  
 Sponges  
 Coastal development  
 Pharmaceuticals  
 Rugosity  
 Shoreline protection  
 Lobsters  
 Ecosystem Restoration  
 Water Quality

## .....how can we make any sense of them?

# DPSIR Systems Framework as a Tool





ReefLink Database | ORD | US EPA - Windows Internet Explorer

US EPA <http://www.epa.gov/ged/coralreef/>

File Edit View Favorites Tools Help

★ Favorites Relevant Journals in Marine ... stats Conditional Probability US EPA One EPA Workplace US EPA My Workplace One EPA Wo... 8 Google

US EPA ReefLink Database | ORD | US EPA

Advanced Search A-Z Index

ReefLink Database

Learn the Issues Science & Technology Laws & Regulations About EPA

ReefLink Database

ReefLink Database  
Economic Drivers  
Pressures  
Reef Ecosystem  
Ecosystem Services  
Responses  
Whole Systems Model  
Topic List & Glossary  
User's Guide  
Tutorial on Systems Thinking

You are here: [EPA Home](#) » [Research](#) » ReefLink Database

## ReefLink Database

### A Decision Support Tool for Linking Coral Reefs and Society through Systems Thinking

This scientific and management information database utilizes [systems thinking](#) to describe the linkages between decisions, human activities, and provisioning of reef ecosystem goods and services. This database provides:

- Hierarchy of related topics - Click on topics below to navigate to sub-topics or related topics
- Four kinds of information for each topic - Concept maps, scientific citations, management options, and laws
- Three ways of searching for topics - Navigate through individual concept maps below, or see the [Whole systems model](#) or search for keywords from a [Topic list](#).

For more information on [how you can use this database](#), see the [user's guide](#).

[Cmap](#) [Citations](#) [Management Options](#) [Laws](#)

### Concept Map

Concept maps (Cmaps) visually represent relationships between concepts.

- Identify which [Socio-Economic Drivers](#) create [Pressures](#) on the reef through human activities.
- Understand how [Reef Ecosystem](#) condition may impact [Ecosystem Goods and Services](#) which benefit society.
- Identify potential management or regulatory [Responses](#) to reduce impacts on environmental resources.
- Select sub-topics or related topics to expand the Cmap and see more detailed information.

```

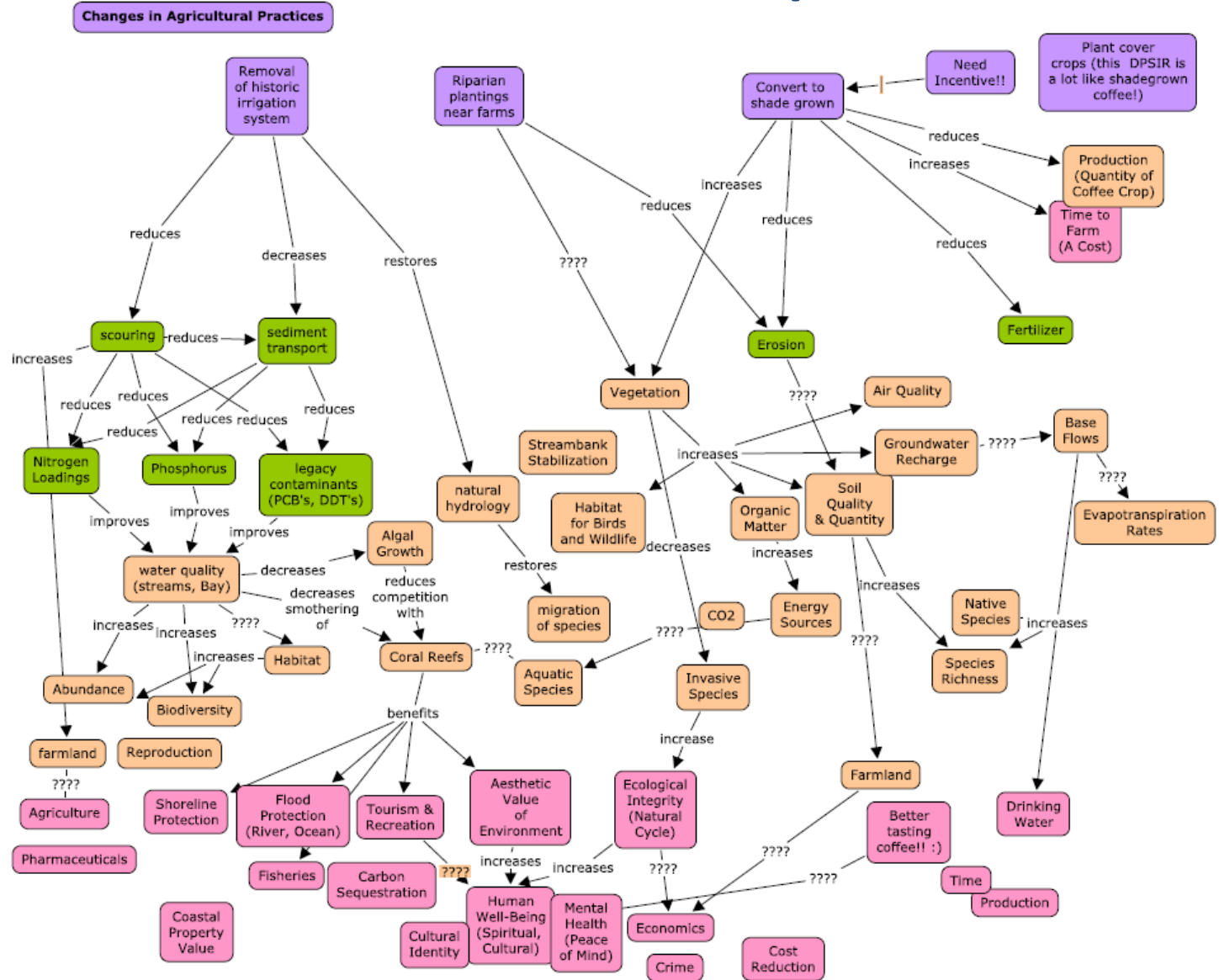
graph TD
    SED[Socio-Economic Drivers] -- create --> PHA[Pressures through Human Activities]
    PHA -- "affect condition of" --> RE[Reef Ecosystem]
    RE -- "impacts availability of" --> ES[Ecosystem Services]
    ES -- "benefit" --> RD[Responses & Decisions]
    RD -- "elicit" --> SED
    RD -- "modify & control" --> SED
    RD -- "maintain & restore" --> RE
    RD -- "modify & control" --> PHA
  
```

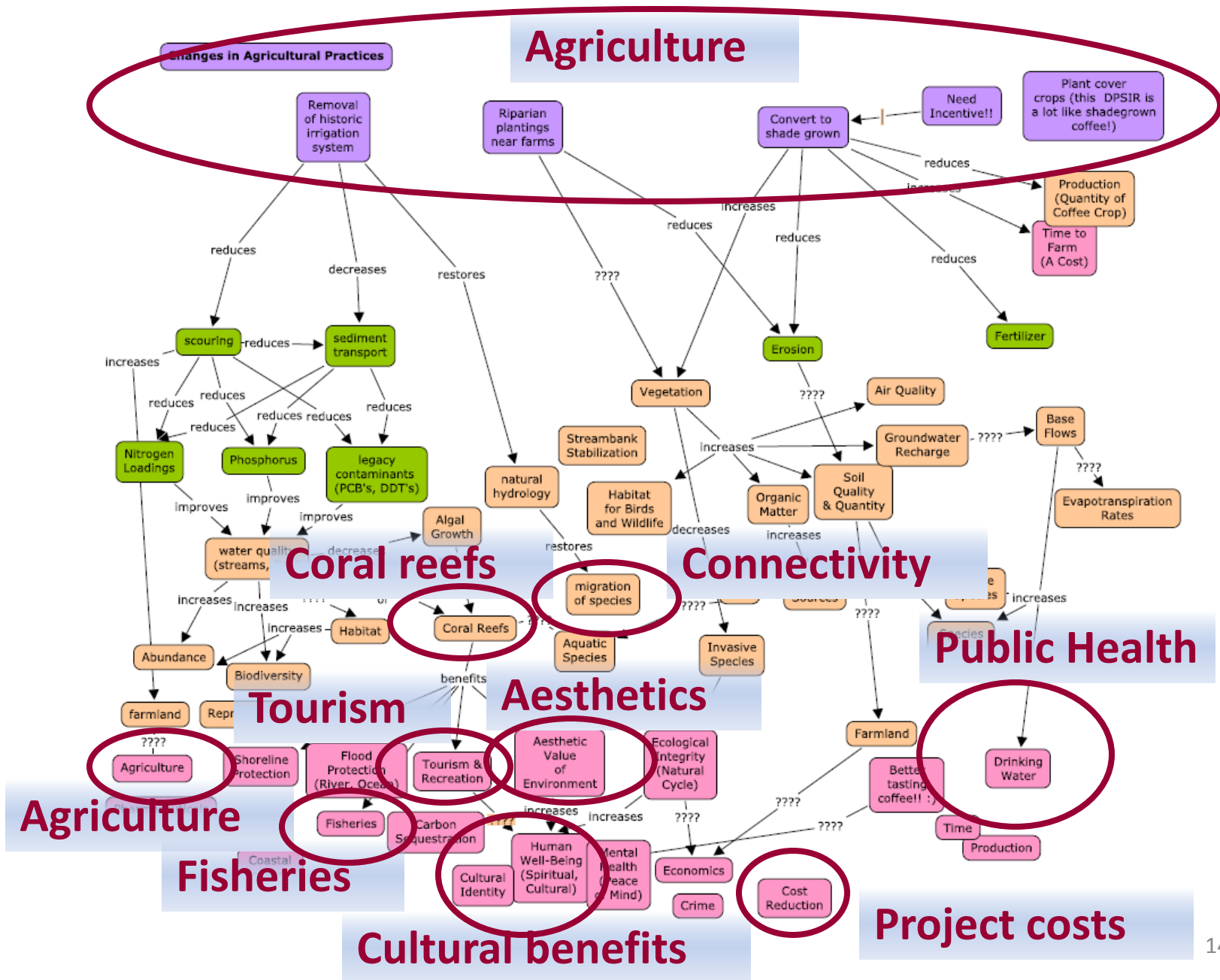
Local intranet 75%

<http://www.epa.gov/ged/coralreef>



# Breakout Group





# Guanica Bay Watershed Management Plan

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Shade-grown coffee

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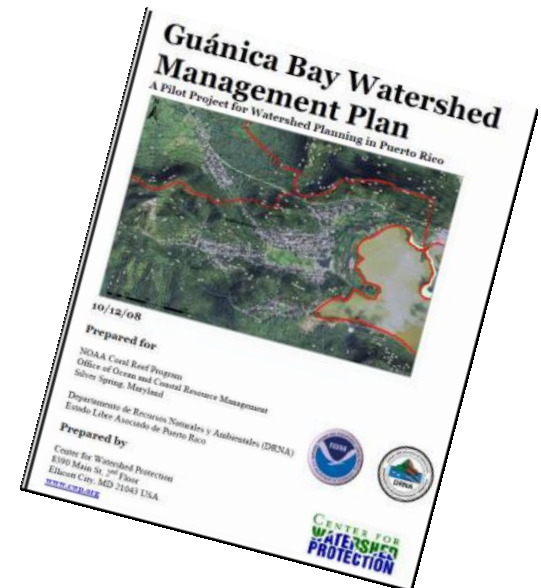
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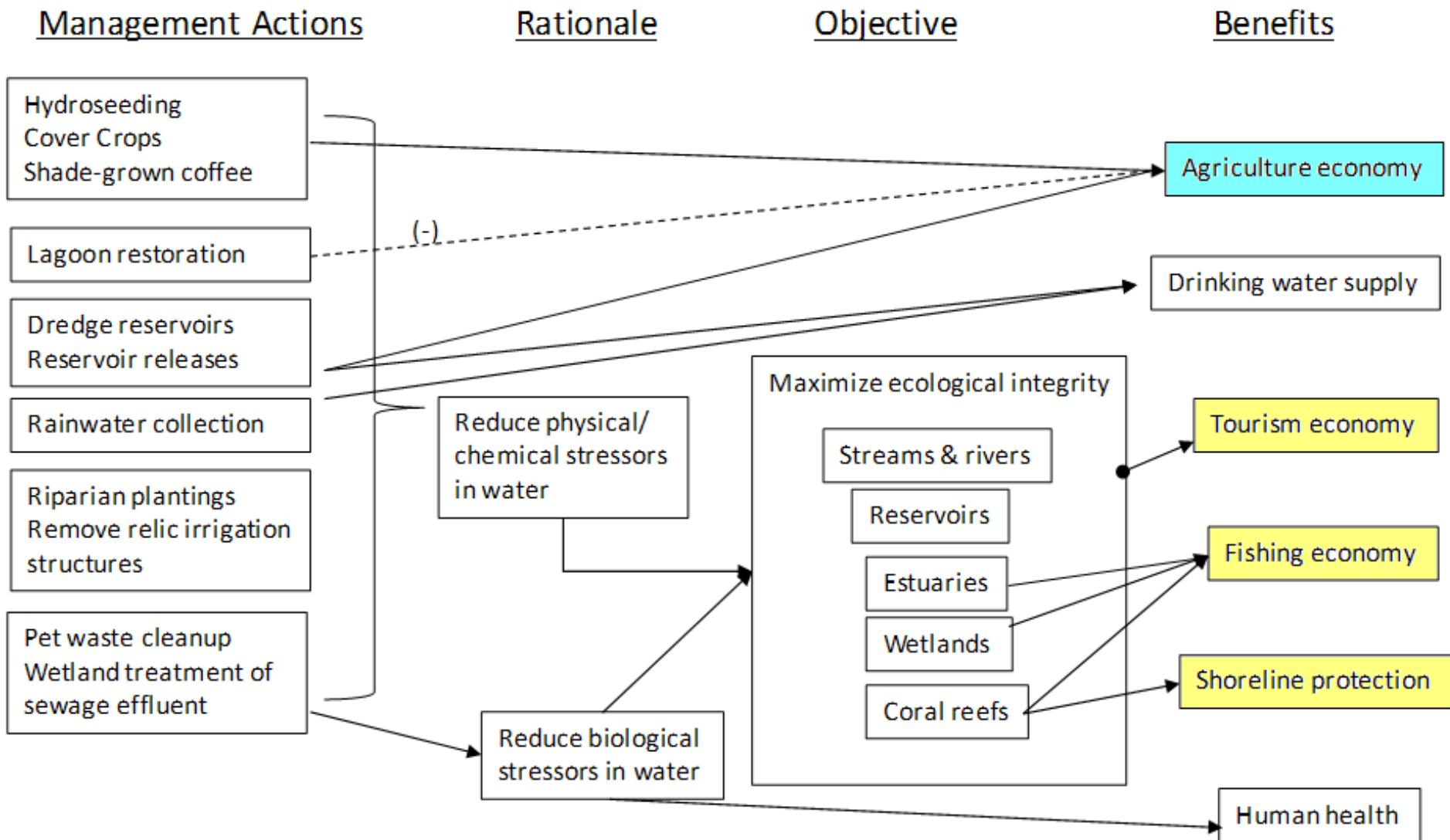
## Objective

Maximize ecological integrity

Coral reefs



# Expanding the Objectives





# Broadening the Decision Context

## Fundamental Objectives

### Maximize Ecological Integrity

- Species abundance, diversity
- Foodweb integrity, habitat

### Maximize economic benefits/minimize economic costs

- Commercial fisheries, tourism, agriculture
- Property values

### Maximize social well-being

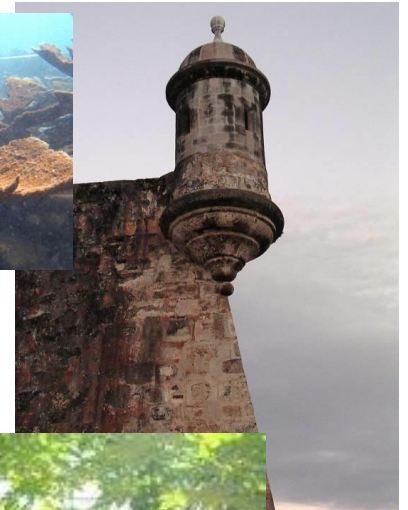
- Employment, recreation
- Historical and aesthetic significance,
- Equity

### Minimize adverse human health effects

- Potable water, sanitation

### Maximize learning opportunities

- Educational opportunities, value of opportunities



# Means - Ends Network

## Fundamental (ends) objectives

## Means objectives



# Management Goal

## Coral Reef Biocriteria Example

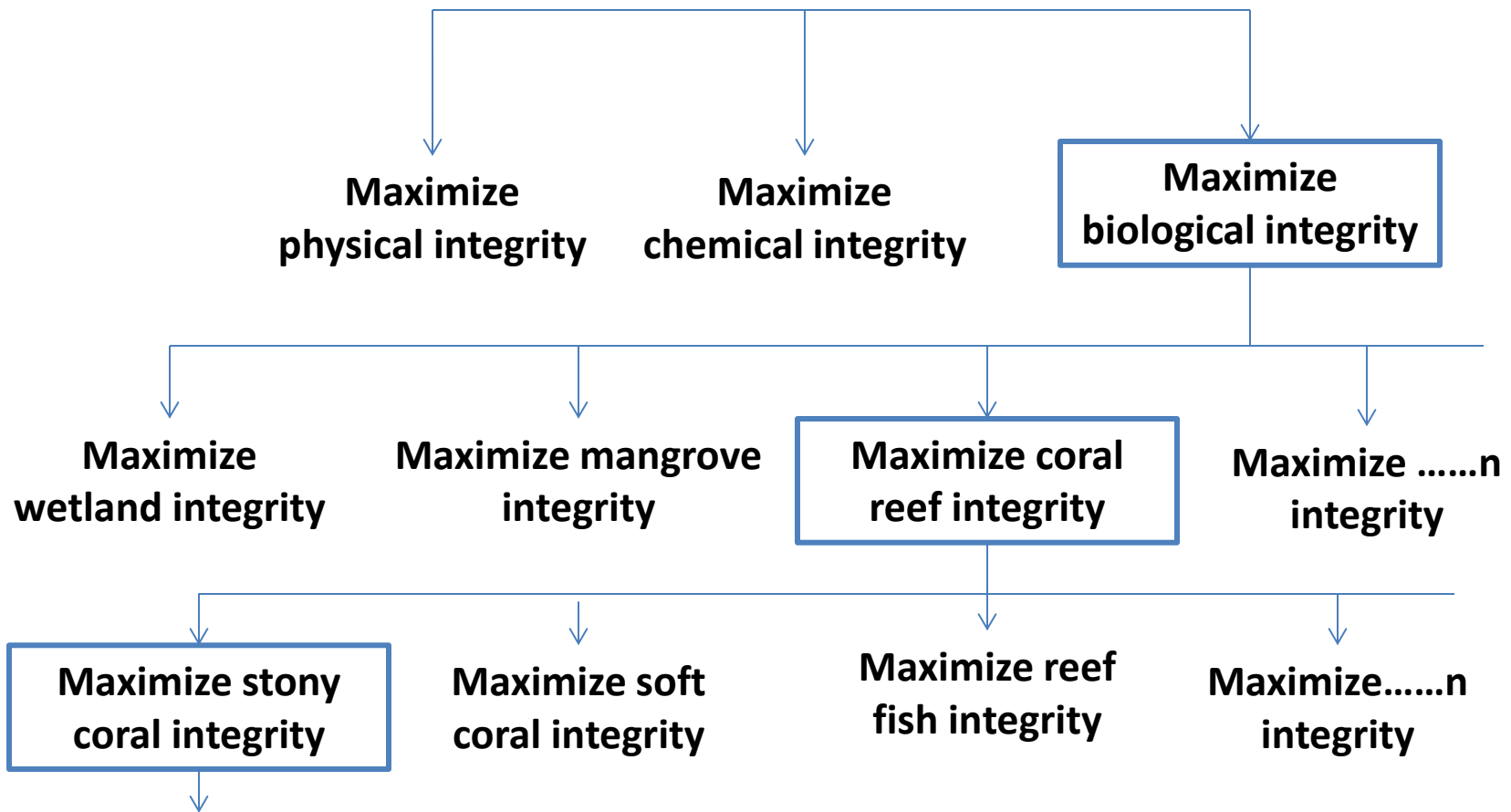
Goal: *Protect and restore coral reef integrity using biological criteria under water quality standards of the Clean Water Act*

Clean Water Act (CWA): *to restore and maintain the physical, chemical and biological integrity of the Nation's waters*

Biological criteria: *thresholds that define biological integrity*

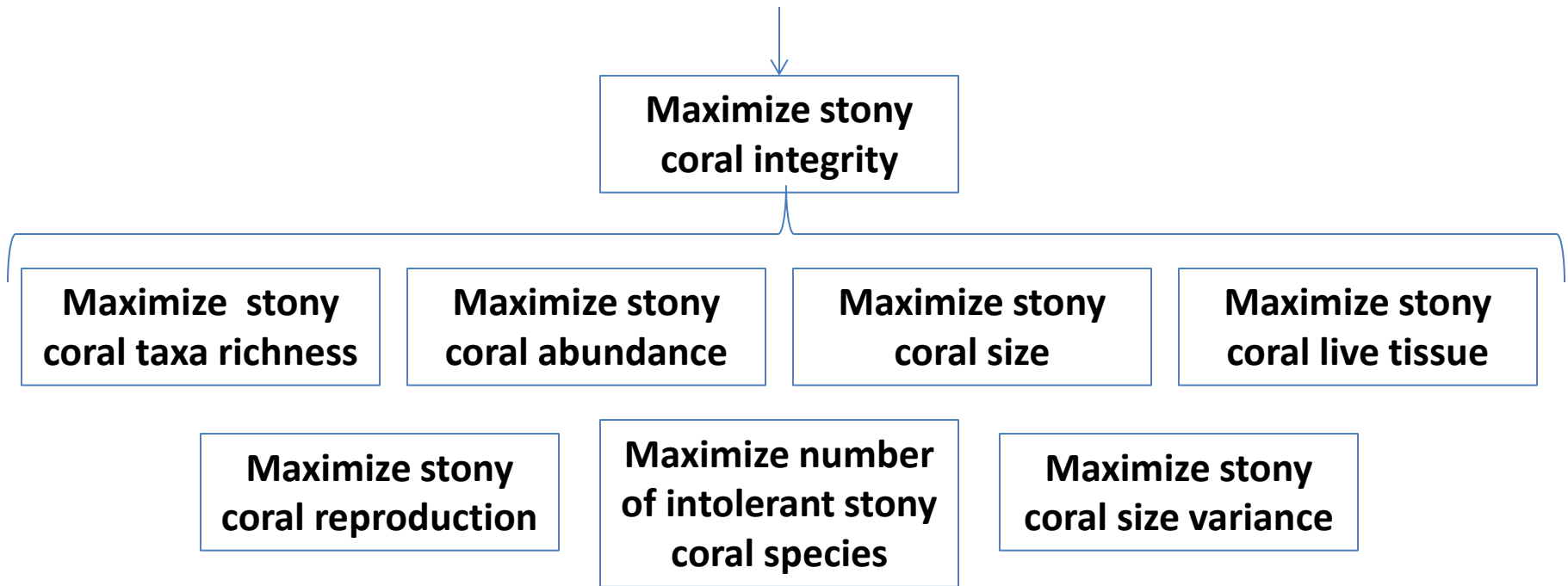


## CWA: maximize physical, chemical and biological integrity of water bodies



An ***objectives hierarchy*** says nothing about how to achieve objectives or measure progress but brings a simple order and transparency to complex issues





These are measurable attributes that can be evaluated as candidate ***performance indicators***

A performance indicator is intended to reflect changes to attributes generated by management actions, so it has to be relevant to management objectives and decisions....

The number of brightly striped fish can be measured, but this doesn't necessarily make it a good indicator for a goal to increase ecosystem integrity.....



....but it might be a good indicator for a goal to increase tourism

## Setting Thresholds



In our example, we have measurements across the region using 'disturbance-sensitive' indicators---how can we use this to determine the levels that attain or fail our goals?

We could begin by asking the experts.....

# Coral Reef Condition

Condition  
(Integrity)



**VERY GOOD –  
EXCELLENT**



**GOOD**



**FAIR**



**POOR**

Experts were asked to grade stations into categories; and to characterize the reasons for their ratings

Ultimately, they agreed on four categories with descriptions of the attributes in each



# Coral Reef Condition

Condition  
(Integrity)



**VERY GOOD –  
EXCELLENT**

Natural  
Refuges; Parks



**GOOD**



**FAIR**



**POOR**

Urban; Industrial  
Impacted



# Coral Reef Biological Condition Gradient



**VERY GOOD –  
EXCELLENT**

BCG: linking  
resource condition  
to severity of stress

**GOOD**



**FAIR**



**POOR**



Refuges,  
parks

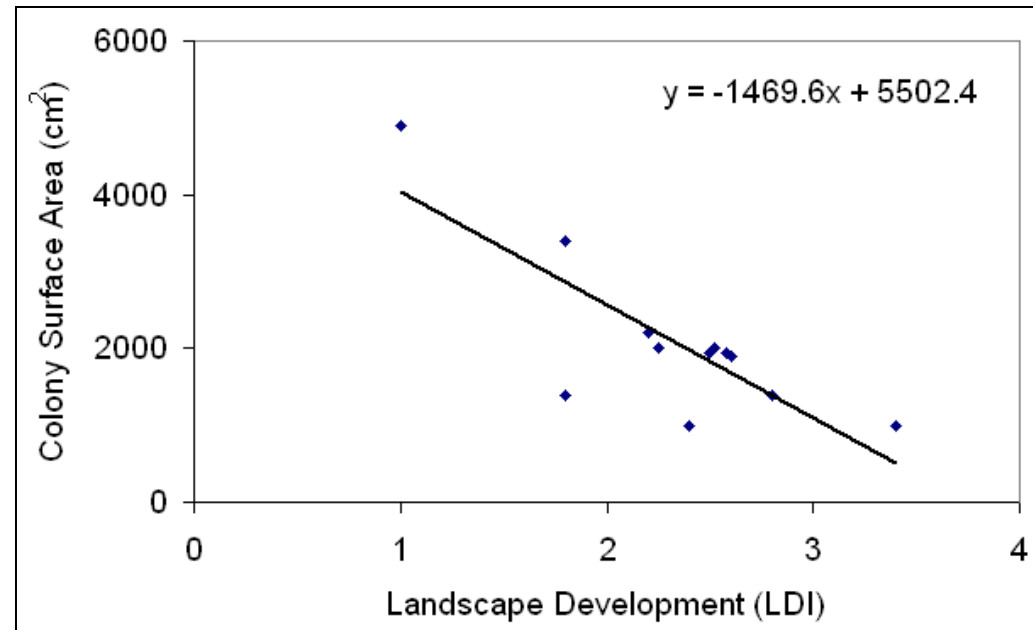
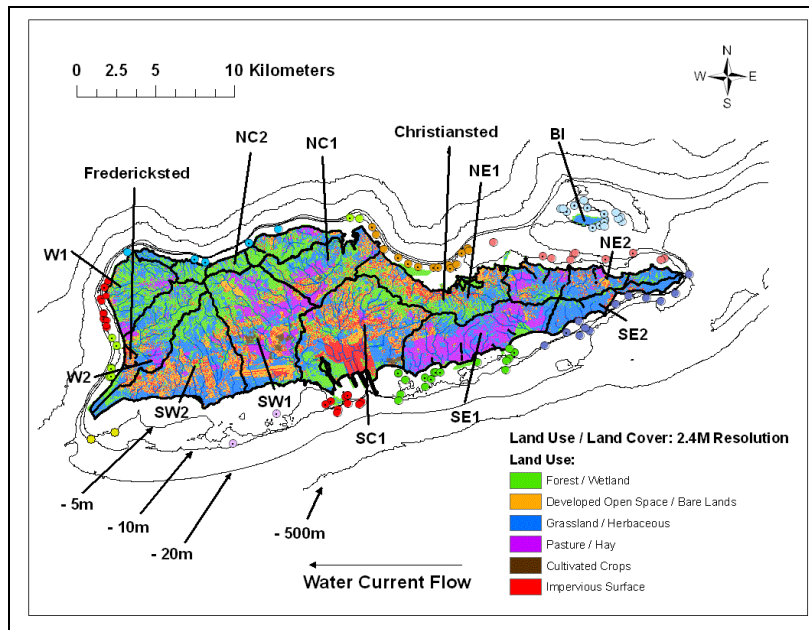
Urban,  
industrial

Condition

Stress

# Linking Stressors to Reef Condition

## Landscape Development Intensity Index (LDI)



These same indicators additional data showed a response to watershed disturbance

# Coral Reef Biological Condition Gradient



**VERY GOOD –  
EXCELLENT**



**GOOD**



**FAIR**



**POOR**

Condition

1

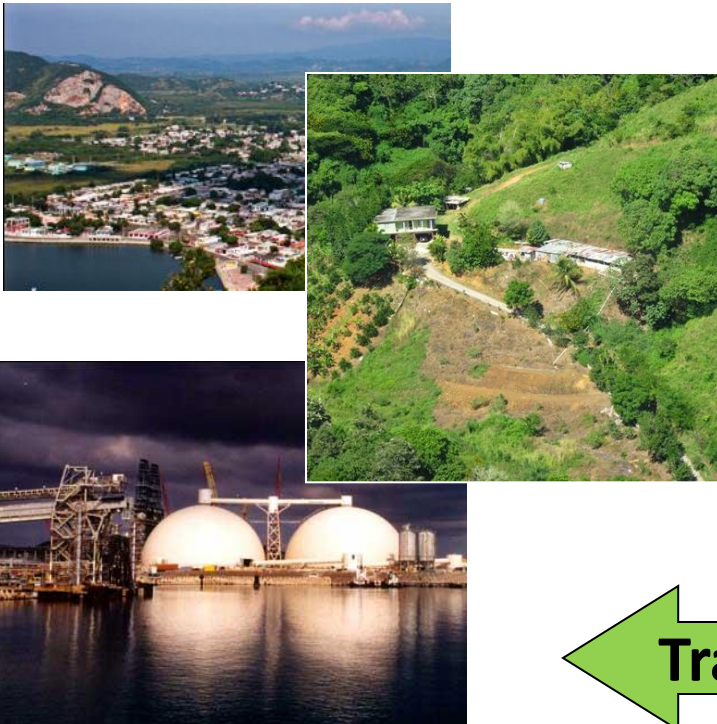
2

3

LDI or some other measure of watershed stress

# Decisions: Maximize social, economic and environmental benefits

## Landuse Decisions



## Ecosystem Services



**Establish quantifiable relationships**



# Evaluation Decision Options for Multiple Objectives

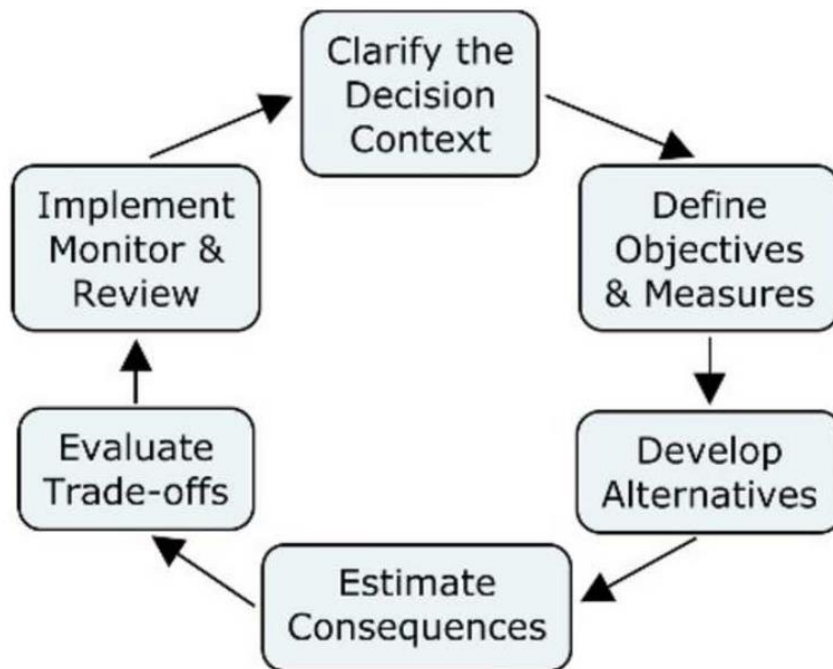
	Option 1	Option 2	Option 3	Option 3a	Etc...
Coral Reefs					
Agriculture					
Tourism					
Public Health					
Cost					
Etc.....					

# Evaluation Decision Options for Multiple Objectives

	Option 1	Option 2	Option 3	Option 3a	Etc...
Coral Reefs	↑	↑	↑	↑	...
Agriculture	↓	↓	↔	↔	...
Tourism	↑	↓	↑	↓	...
Public Health	↔	↑	↔	↑	...
Cost	↓	↑	↔	↑	...
Etc.....	...	...	...	...	...

# Structured Decision Making

A process to elicit and organize key *stakeholder values* and relevant *scientific knowledge* for making decisions



## Strengths of SDM

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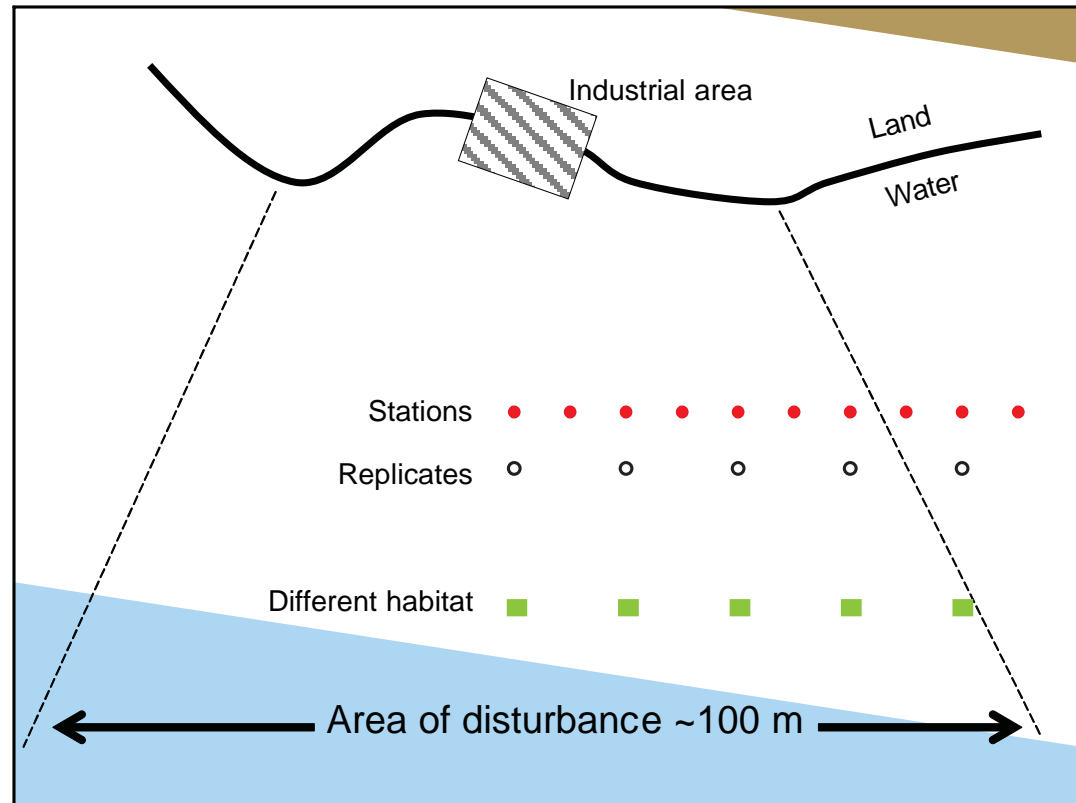
**Thank you**



**[fisher.william@epa.gov](mailto:fisher.william@epa.gov)**

# Screening Indicators for Sensitivity to Human Disturbance

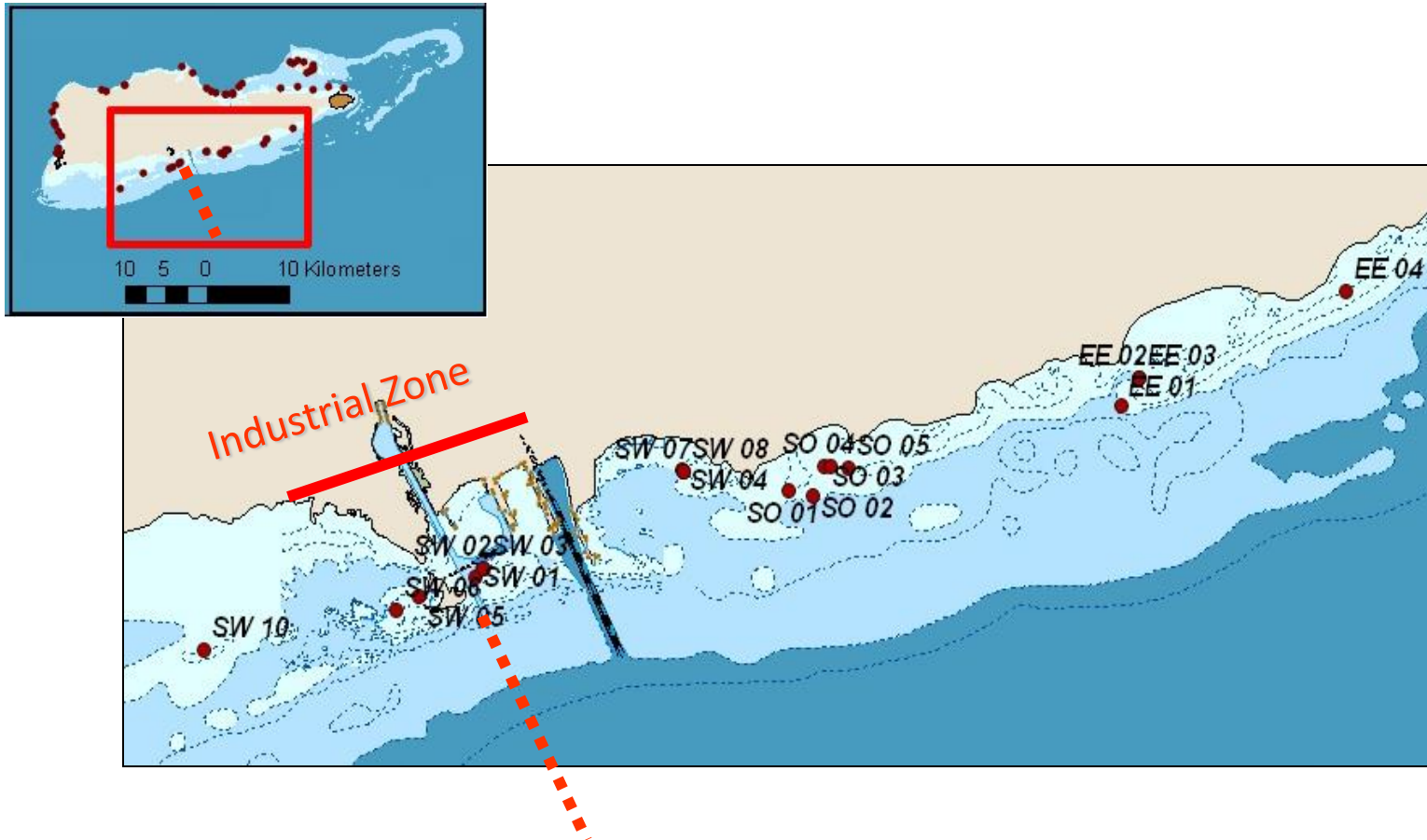
Evaluate indicator measurements at stations across a human disturbance gradient



Not required to know specifically what the stressor is; just that human activity is high

# Human Disturbance Gradient

## St. Croix, USVI

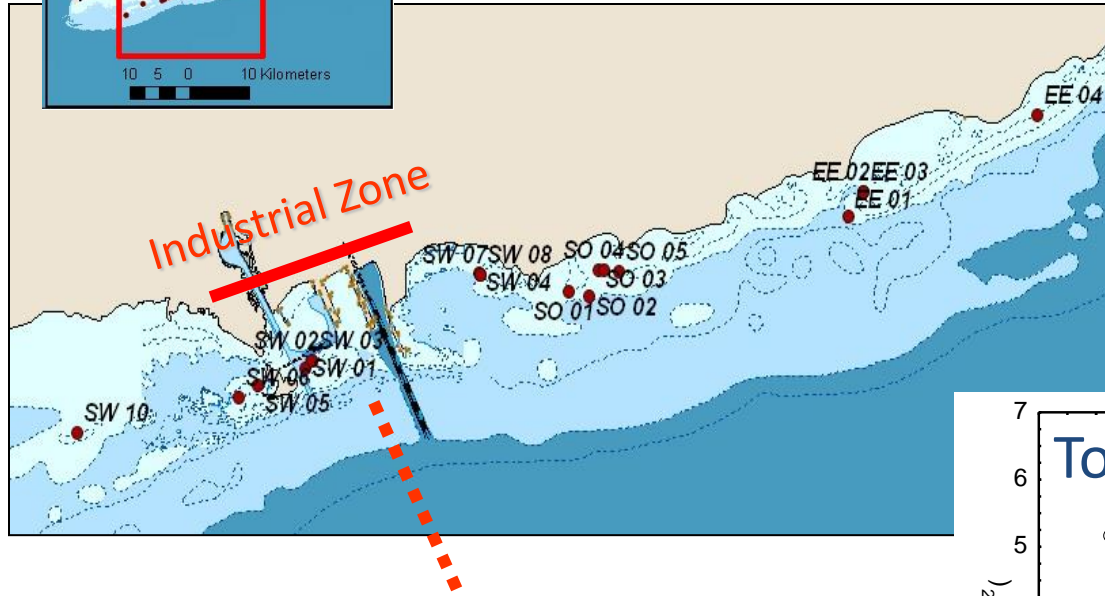
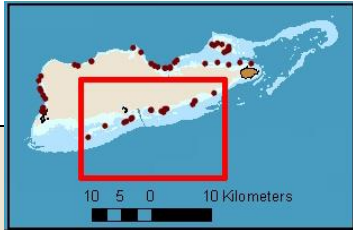


Industrial docks =  
center of human disturbance



# Human Disturbance Gradient

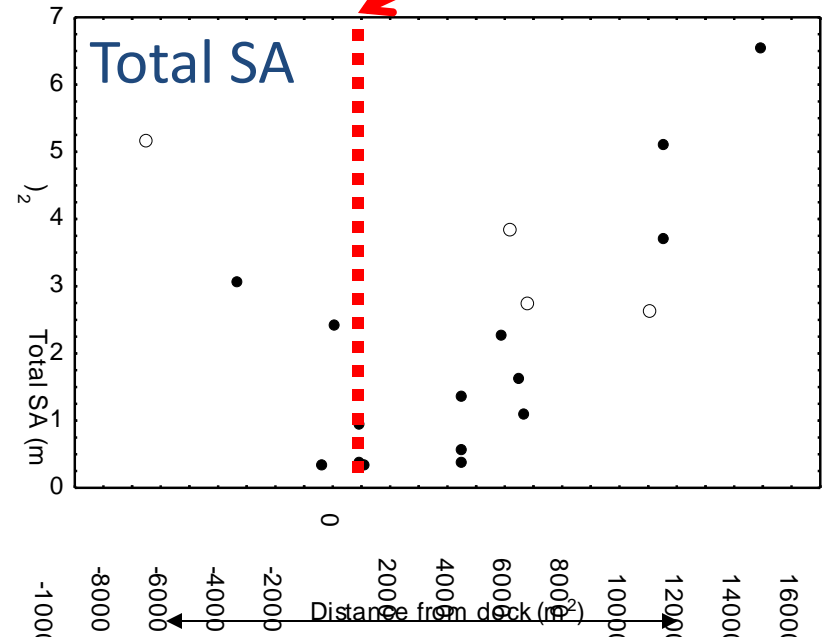
## St. Croix, USVI





Industrial docks =  
center of human disturbance

Center of disturbance

Demonstrated a decline in  
condition relative to a  
'point' disturbance



Condition Level	Attributes
<p><b>POOR</b></p> <p><b>(Approximate BCG level 6)</b></p> 	<p><b>Physical structure:</b> Very low rugosity, no or low reef built above bedrock; no or low relief for fish habitat, very turbid water; thick sediment film and high flocs covering bottom, no substrate for recruits</p> <p><b>Corals:</b> Absence of colonies, those present are small, only highly tolerant species, little or no tissue</p> <p><b>Condition:</b> High prevalence of disease on small colonies of corals, sponges, &amp; gorgonians, if present low or no tissue coverage</p> <p><b>Sponges:</b> Heterotrophic sponges buried deep in sediment, highly tolerant sponge species</p> <p><b>Gorgonians:</b> Small &amp; sparse colonies, mostly small sea fans, often diseased</p> <p><b>Fish:</b> No large fish, few tolerant species, lack of multiple trophic levels</p> <p><b>Vertebrates:</b> Usually devoid of other vertebrates</p> <p><b>Other invertebrates:</b> Few or no reef invertebrates, high abundance of sediment dwelling organisms as polychaetes, holothurians</p> <p><b>Algae/plants:</b> high cover of fleshy algae (<i>Dictyota</i>); possibly smothering sessile invertebrates; no turf or crustose coralline algae</p>

Condition Level	Attributes
<p><b>VERY GOOD – EXCELLENT</b></p> <p><b>(Approximate BCG level 1)</b></p> 	<p><b>Physical structure:</b> High rugosity or 3D structure, substantial reef built above bedrock, many irregular surfaces provide habitat for fish, very clear water, no sediment, flocs or films</p> <p><b>Corals:</b> High species diversity including rare species; large old colonies (<i>Montastraea</i>) with high tissue coverage; balanced population structure (old &amp; middle-aged colonies, recruits); <i>Acropora</i> thickets present</p> <p><b>Condition:</b> Low prevalence disease, tumors, mostly healthy tissue on colonies</p> <p><b>Sponges:</b> Large autotrophic &amp; highly sensitive sponge species abundant</p> <p><b>Gorgonians:</b> Gorgonians present but subdominant to corals</p> <p><b>Fish:</b> Populations have balanced species abundance, sizes &amp; trophic interactions</p> <p><b>Vertebrates:</b> Large, long-lived species present &amp; diverse (turtles, eels, sharks)</p> <p><b>Other invertebrates:</b> <i>Diadema</i>, lobster, small crustaceans &amp; polychaetes abundant, some large sensitive anemone species</p> <p><b>Algae/plants:</b> Crustose coralline algae abundant, turf algae present but cropped &amp; grazed by <i>Diadema</i> or other herbivores, low abundance fleshy algae</p>

# Coral Reef Condition

Condition  
(Integrity)



**VERY GOOD –  
EXCELLENT**



**GOOD**



**FAIR**



**POOR**

Refuges; Parks



Urban; Industrial

# Coral Reef Condition

Condition  
(Integrity)



**VERY GOOD –  
EXCELLENT**

Historical Evidence



**GOOD**



**FAIR**



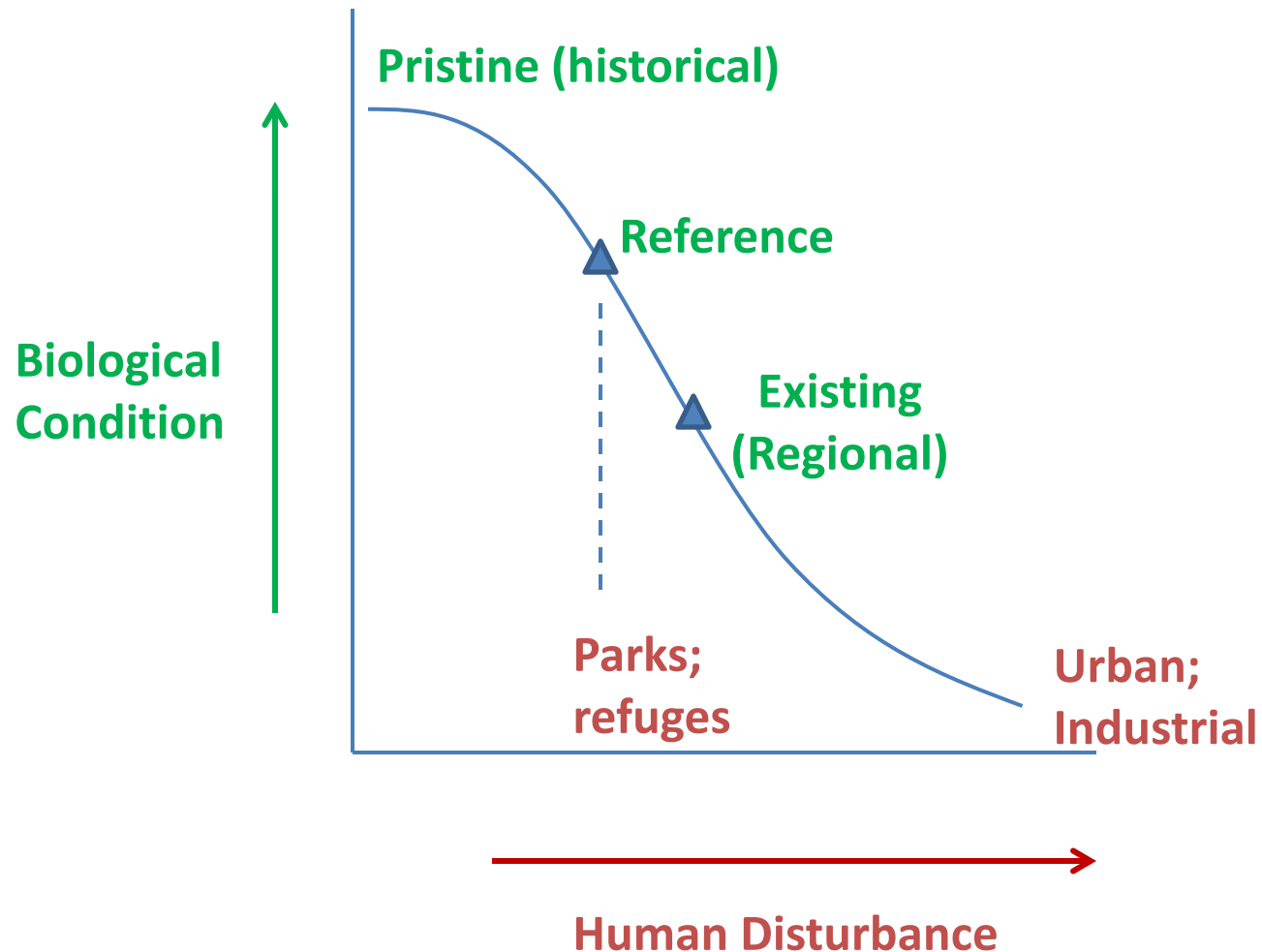
**POOR**

Refuges; Parks

Urban; Industrial

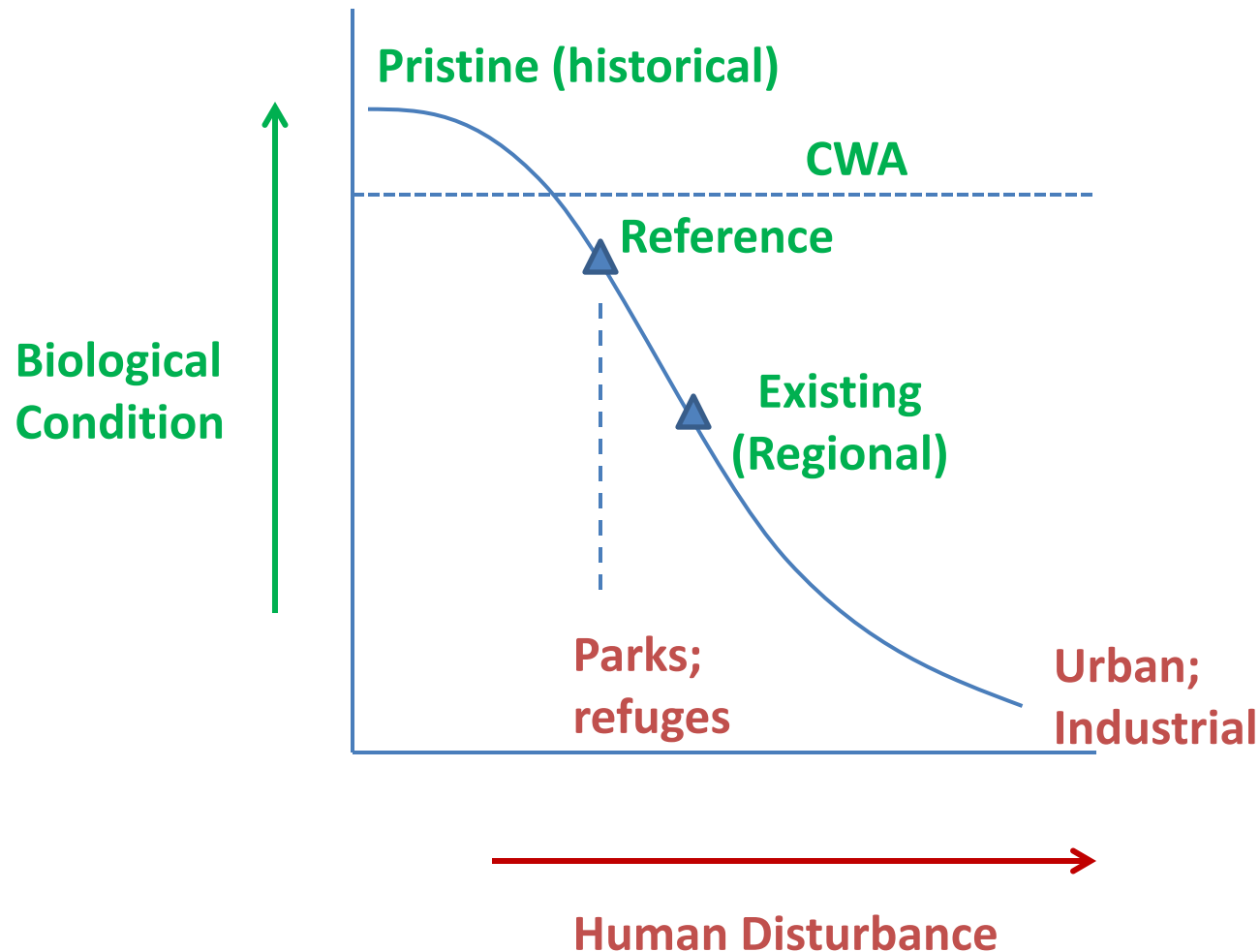


# Relation of Condition to Disturbance

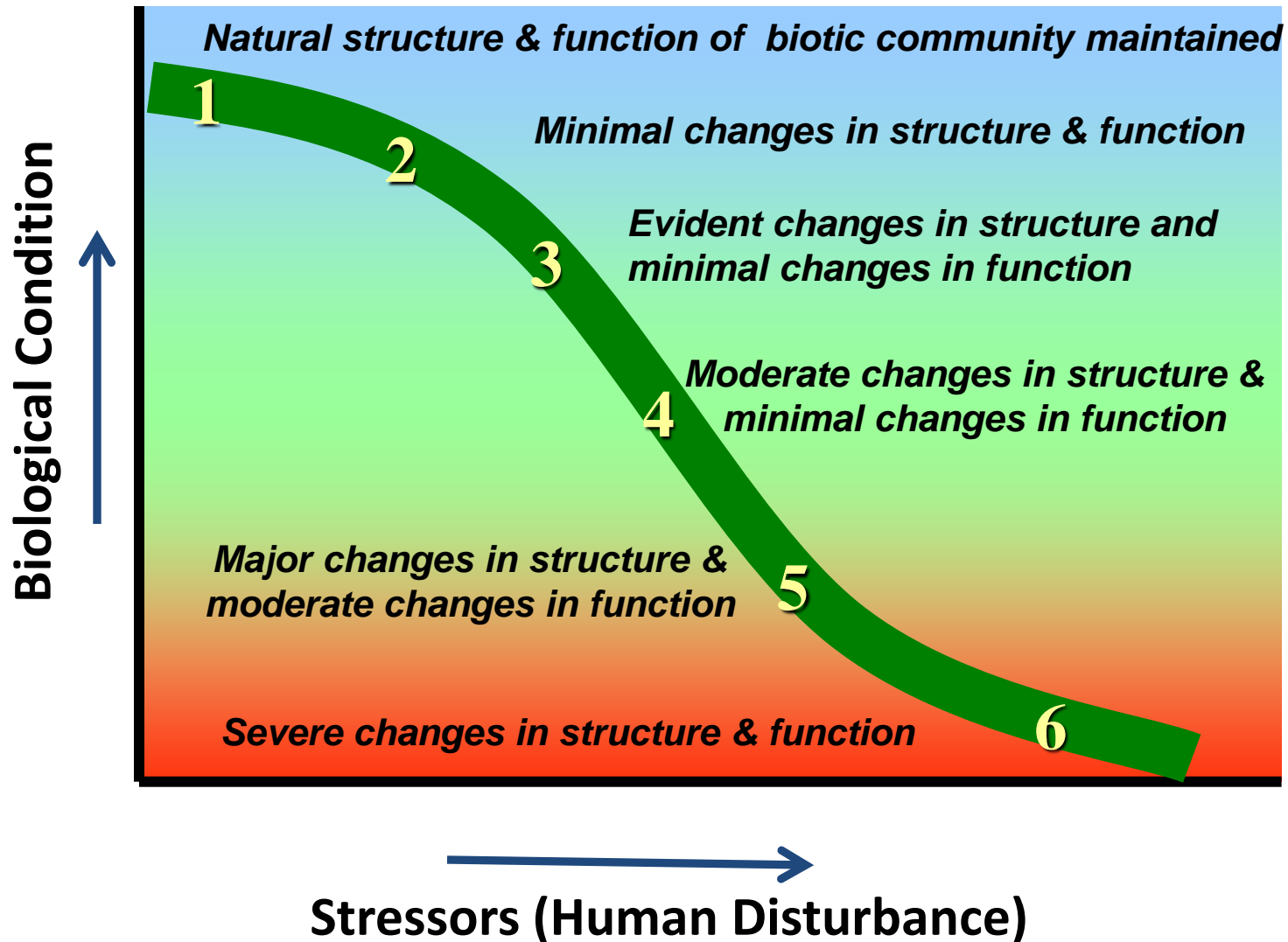




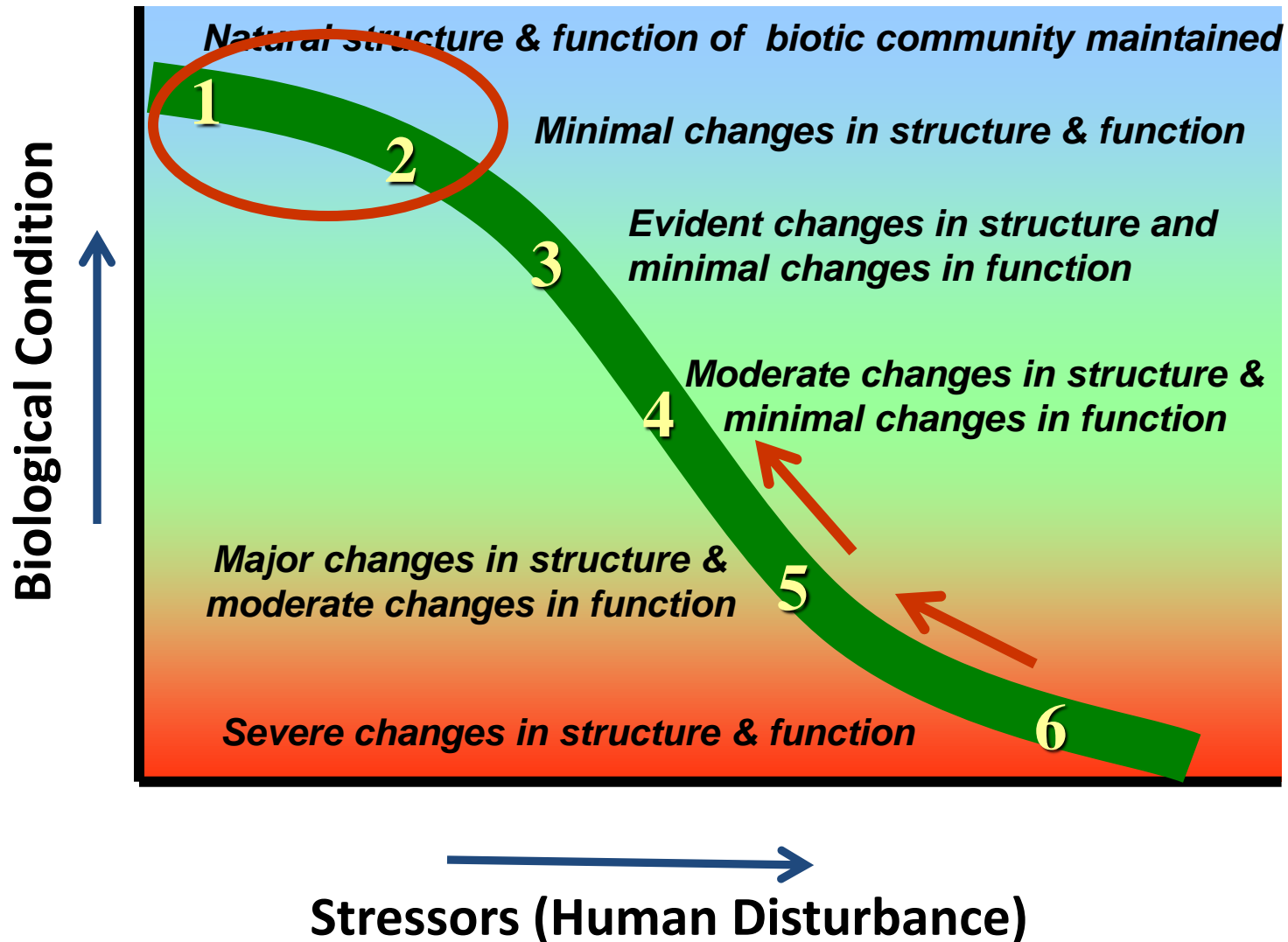
# Relation of Condition to Disturbance



# Biological Condition Gradient (BCG)



# Biological Condition Gradient (BCG)



## Biological Integrity:

*The ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the **natural habitats within a region.***



## Biological Integrity:

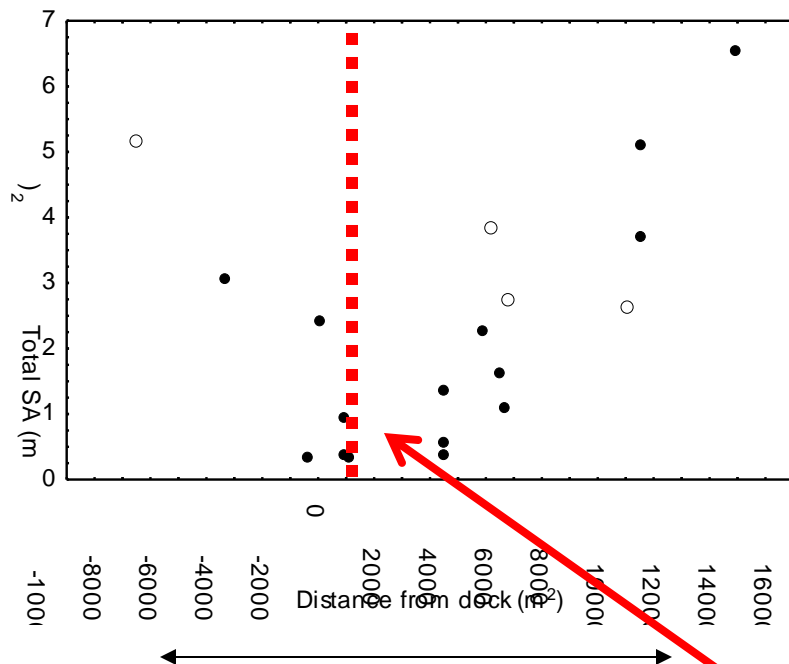
*The ability of an aquatic ecosystem to support and maintain **a balanced, integrated, adaptive community of organisms** having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region.*



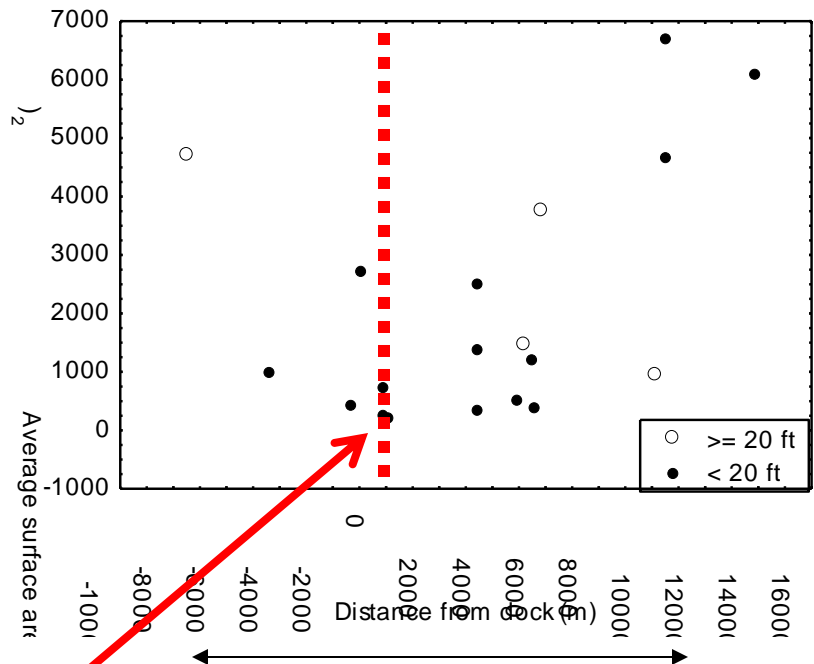


# Responsive Indicators

## Total Surface Area



## Average Colony Size



Center of disturbance